

Assignment 1

1)

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1)

```

graph TD
    e --> n
    n --> nd
    nd --> dcl
    dcl --> 2d
    2d --> 25
  
```

$e ::= n$
 $e ::= e + e$
 $e ::= e - e$
 $n ::= d$
 $n ::= nd$
 $d ::= 0$
 $d ::= 1$
 \dots
 $d ::= 9$

derivation: $e \rightarrow n \rightarrow nd \rightarrow dcl \rightarrow 2d \rightarrow 25$
 2nd deviation: $e \rightarrow n \rightarrow nd \rightarrow ns \rightarrow ds \rightarrow 25$
 There is not another parse tree.

2) a) $1 - (* 1)$

```

graph TD
    e --> e_minus_e[e - e]
    e_minus_e --> 1
    e_minus_e --> e_star_e[e * e]
  
```

b) $1 - (1 + 1)$

```

graph TD
    e --> e_minus_e[e - e]
    e_minus_e --> 1
    e_minus_e --> e_plus_e[e + e]
  
```

2)

$d ::= 1$
 \dots
 $d ::= 9$

2) a) $1 - (* 1)$

```

graph TD
    e --> e_minus_e[e - e]
    e_minus_e --> 1
    e_minus_e --> e_star_e[e * e]
    e_star_e --> 1
    e_star_e --> 1
  
```

$e ::= 0 \mid 1 \mid (e + e) \mid (e - e) \mid (e * e)$

b) $1 - (1 + 1)$

```

graph TD
    e --> e_minus_e[e - e]
    e_minus_e --> 1
    e_minus_e --> e_plus_e[e + e]
    e_plus_e --> 1
    e_plus_e --> 1
  
```

$e ::= 0 \mid 1 \mid (e + e) \mid (e * e)$

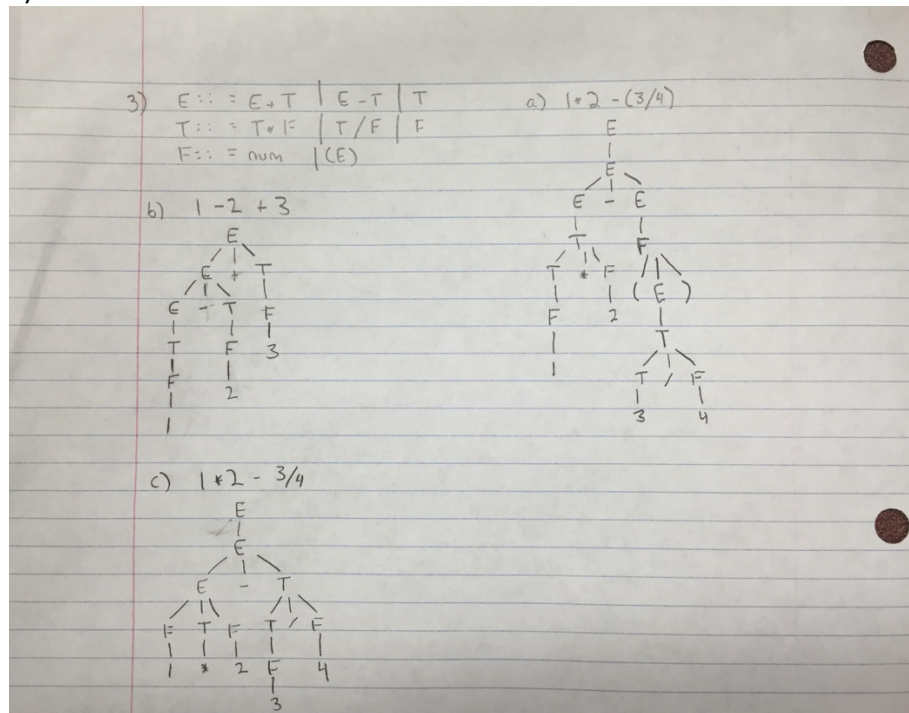
c) $1 - (1 + 1 - 1 + 1)$

```

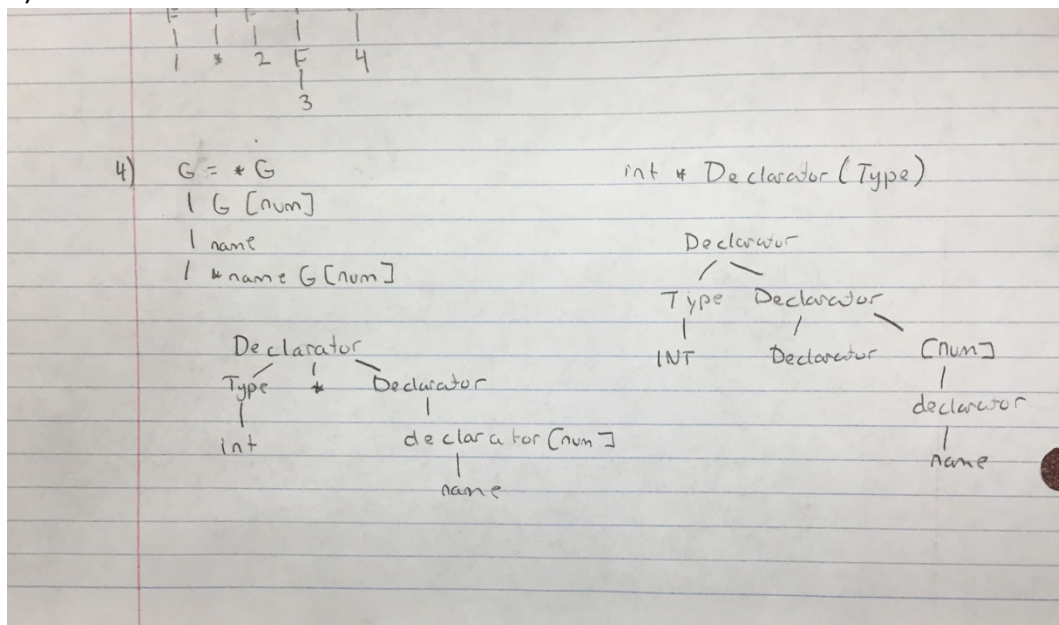
graph TD
    e --> e_minus_e[e - e]
    e_minus_e --> 1
    e_minus_e --> e_plus_e[e + e]
    e_plus_e --> e_minus_e2[e - e]
    e_plus_e --> e_plus_e2[e + e]
    e_minus_e2 --> 1
    e_minus_e2 --> 1
    e_plus_e2 --> 1
    e_plus_e2 --> 1
  
```

$e ::= 0 \mid 1 \mid (e + e) \mid (e - e) \mid (e * e)$

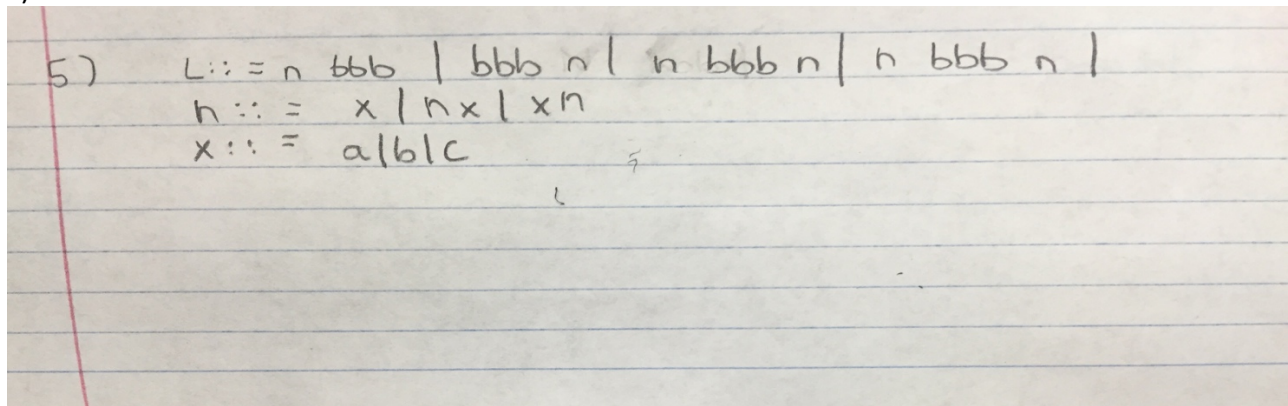
3)



4)



5)



6)

$e ::= n \mid x \mid x := e \mid e + e$

a)

$\langle x + y, \sigma \rangle \rightarrow$

$\langle 2 + y, \sigma \rangle \rightarrow$

$\langle 2 + 3, \sigma \rangle \rightarrow$

$\langle 5, \sigma \rangle$

b)

$\langle x := x + 3, \sigma \rangle \rightarrow$

$\langle x := 1 + 3, \sigma \rangle \rightarrow$

$\langle x := 4, \sigma \rangle \rightarrow$

$\langle 4, \sigma(x:=4) \rangle c) \langle (x:=3) + x, \sigma \rangle \rightarrow$

$\langle 3 + x, \sigma(x=3) \rangle \rightarrow$

$\langle 3 + 3, \sigma(x:=3) \rangle \rightarrow$

$\langle 6, \sigma(x:=3) \rangle$

d)

$\langle x := (x := x + 3) + (x := x + 5), \sigma \rangle \rightarrow$

$\langle x := (x := 1 + 3) + (x := x + 5), \sigma \rangle \rightarrow$

$\langle x := (x := 4) + (x := x + 5), \sigma \rangle \rightarrow$

$\langle x := 4 + (x := x + 5), \sigma(x=4) \rangle \rightarrow$

$\langle (x:=4 + (x:=4+5)), \sigma(x:=4) \rangle \rightarrow$

$\langle x := 4 + (x := 9), \sigma(x:=4) \rangle \rightarrow$

$\langle x:=4 + 9, \sigma(x:=9) \rangle \rightarrow$

$\langle x := 13, \sigma(x:=9) \rangle \rightarrow$

$\langle 13, \sigma(x:=13) \rangle$